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To cite this article: Edward N. Mwavu, Esther Ariango, Paul Ssegawa, Vettes N. Kalema, Fred Bateganya, Daniel Waiswa & Patrick Byakagaba (2016) Agrobiodiversity of homegardens in a commercial sugarcane cultivation land matrix in Uganda, International Journal of Biodiversity Science, Ecosystem Services & Management, 12:3, 191-201, DOI: [10.1080/21513732.2016.1177595](https://doi.org/10.1080/21513732.2016.1177595)

To link to this article: <https://doi.org/10.1080/21513732.2016.1177595>



Published online: 03 May 2016.



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Agrobiodiversity of homegardens in a commercial sugarcane cultivation land matrix in Uganda

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ABSTRACT

Understanding biodiversity in homegardens embedded in landscapes dominated by commercial monoculture agriculture is critical for sustainable management of agrobiodiversity and meeting rural households' needs in the face of global changes. We assessed agrobiodiversity in the 120 homegardens and its contribution to rural household livelihood strategies within a commercial monoculture sugarcane cultivation land matrix in eastern Uganda. We recorded a total of 68 plant species from 46 genera representing 27 families. Species richness spanned 6 to 19 species, and α -diversity (H') ranged from 0.6 to 2.3; with 86.67% of the homegardens having $H' > 1$. Species composition differed significantly (global $R_{ANOSIM} = 0.153$, $p < 0.001$) among the villages. The most important and commonly maintained plants were those that provided food, fuelwood and money income and included *Zea mays* L., *Manihot esculenta*, *Phaesolus* spp., *Coffea* sp., *Musa* spp., *Ipomea batatus* and *Artocarpus heterophyllus*. Most of the crops cited as useful by households were also frequent and visible in many of the homegardens. Although homegardens still hold some valuable plants, there is also loss of important plants from the agricultural system including cowpeas, soya beans, bambara groundnuts, finger millet, cotton, aerial yams and oysternut essential for sustaining household livelihoods. This loss, precipitated by increased land-use/cover change to commercial sugarcane plantations threatens agrobiodiversity conservation and the benefits households derive from homegardens. Our findings underline the importance of homegardens in the conservation of indigenous agrobiodiversity, and indicate that with the continued expansion of commercial sugarcane cultivation this opportunity may be lost.

ARTICLE HISTORY

Received 20 July 2015
Accepted 7 April 2016

EDITED BY

Christine Fürst

KEYWORDS

ANalysis Of SIMilarity (ANOSIM); biodiversity; climate change; commercial agriculture; food security; homegardens; rural livelihoods; SIMilarity PERcentages (SIMPER)

Introduction

Understanding the current status and forecasting the future state of tropical biodiversity requires that we understand the levels and patterns of agrobiodiversity in landscapes actively managed and modified by humans for a wide variety of traditional and commercial purposes, including commercial agriculture (Bawa et al. 2004; Butler et al. 2007; Chazdon et al. 2009). The drive for economic development mainly based on intensification of commercial monoculture agriculture is leading to increasing land-use/cover changes in many developing tropical countries. These land use/cover changes are a global concern as land surface processes impact on ecosystem goods and services (Lambin et al. 2003); and many of the drivers of biodiversity loss across all tropical ecosystems are associated with the intensification of agriculture (Hails 2002; Green et al. 2005; Donald & Evans 2006). In sub-Saharan Africa, land-use/cover change is driven largely by the increasing demand for

more land to meet and improve food security, alleviate poverty and enhance the human and social welfare at household and community levels (Maitima & Gumbo 2007). These processes might affect the abundance and distribution of native biodiversity including agriculture biodiversity (i.e. agrobiodiversity) by changing the landscape structure over time and space (Wiens 1989).

In Uganda, like other sub-Saharan African countries, increasing efforts for poverty alleviation and wealth creation by the government have moved commercial firms and households to adopt commercial agriculture leading to expansive lands of monocultures (incl. oil palms, sugarcane, tobacco, sunflower) in historically forested and subsistence-oriented agriculture production systems. In the eastern part of Uganda, particularly the Busoga sub-region, commercial monoculture sugarcane growing that offers attractive incentives both to the Uganda government and the rural communities dominates the cultivated landscape. Consequently, there have been changes in

the landscape resulting in a commercial sugarcane plantations land matrix, interspersed with small patches of homegardens where a range of plants that are important to households is maintained. In this study, a homegarden is regarded as the area around a homestead or peridomestic area where household members plant and tend useful plants including food crops, herbs, fruits, medicinal plants, fuelwood and ornamental plants (Rugalema et al. 1994; Howard 2006; Perrault-Archambault & Coomes 2008). Worldwide, sugarcane crop cultivation has progressively increased but sustaining this monoculture increase while ensuring minimal environmental impact is a major challenge (Lakshmanan et al. 2005).

Although commercial sugarcane cultivation improves household incomes and road infrastructure in areas where it is practiced in Uganda, it is taking up most of the land previously used for subsistence agriculture, leaving only a few patches of homegardens. Moreover, little is known about the implications of such changes in the landscape for agrobiodiversity sustainability, and livelihoods of rural subsistence farming households. Uganda's economy like for many sub-Saharan African countries is predominantly agrarian, depending largely on indigenous agrobiodiversity. Agrobiodiversity includes those components of biological diversity relevant to food and agriculture as well as the components of biological diversity that constitute the agro-ecosystem (Negri & Polegri 2009; Frison et al. 2011), and the knowledge associated with them (Jackson et al. 2007). Conservation of biodiversity is viewed as a means of achieving adaptation strategies for human well-being in the face of climate and land use/cover changes. Its maintenance provides a broad range of essential goods and services, which support ecosystem resilience and productivity (Tilman 1999), thus it is a core principle of sustainable agriculture and agroecology (Altieri & Merrick 1987; Paoletti 2001; Marshall & Moonen 2002). Sustainable development requires the reconciliation of demands for biodiversity conservation and increased agricultural production (Eilu et al. 2003), aided by a clear understanding of the biodiversity within such changing landscapes. An inventory of agrobiodiversity in patches (e.g. homegardens) embedded in a landscape matrix dominated by commercial monoculture agriculture is essential for identification and promotion of appropriate management strategies for conserving biodiversity in tropical regions (e.g. Zuidema & Sayer 2003; Lindenmayer et al. 2008). In addition, understanding the geographical and social distributions of crop species, and the factors that shape patterns of species diversity is crucial to efforts aimed at promoting agrobiodiversity conservation (e.g. Zimmerer 1996; Brush & Meng 1998; Bellon 2004). In this

study, we assessed the dominant notion in literature, which suggests that monocultures cause agrobiodiversity erosion (Masayi & Netondo 2012; Namb & Netondo 2013). We explored the following research questions; (i) What is the species diversity and composition within the homegardens in the villages that are practicing commercial sugarcane growing? (ii) Which plants within the homegardens do households consider to be the most important to their livelihoods and why? (iii) Which benefits do households derive from their homegardens? and (iv) What has been the status of indigenous important plants in the homegardens over the years? In this study, we focus on homegardens as a potential source of agrobiodiversity in a fragmented landscape dominated by commercial monoculture sugarcane plantations, which can be conserved for ecosystem services. We envisage that the findings from the current study will inform future agricultural policies and programs.

Materials and methods

Study area description

The study was conducted in homegardens within villages that are predominantly commercial sugarcane out-grower villages (i.e. areas with sugarcane farmers with contractual obligations with sugar companies) in Jinja and Mayuge districts within a radius of 21 km from Kakira Sugar Works Limited (KSWL) factory in eastern Uganda. Most sugar companies in these districts rely on contracting individual farmers to grow sugarcane for them under the out-grower scheme and therefore they are the most relevant for the current study. The 21 km radius is the area where most of the registered out-growers for KSWL are located and therefore assumed areas of large-scale commercial sugarcane growing. The study area lies at an altitude of 1180 m, and between latitude 00° 30' N and longitude 33° 17' E (Figure 1). It has an undulating topography with an average slope of 5%. The area has a mean annual temperature of 28°C and is characterized by two rain seasons (i.e. March–June and September–December) with a mean annual precipitation of 1283 mm recorded over the last 40 years (Department of Meteorology 2000). The major soil types are rhodilixic ferralsols (Ssendiwayo et al. 1998). Soil texture varies from clay loams/sandy clay loams to sandy loam (Isabirye et al. 2000). The vegetation of the area was originally a mosaic of vegetation/croplands, but it is presently monoculture sugarcane plantations dominated landscape. The 2014 Uganda National and Housing and Population Census estimated the human population of Mayuge district to be about 479,172 people of whom 48.6% were males, while Jinja with 468,256 of whom 48.6% were males (UBOS 2014).

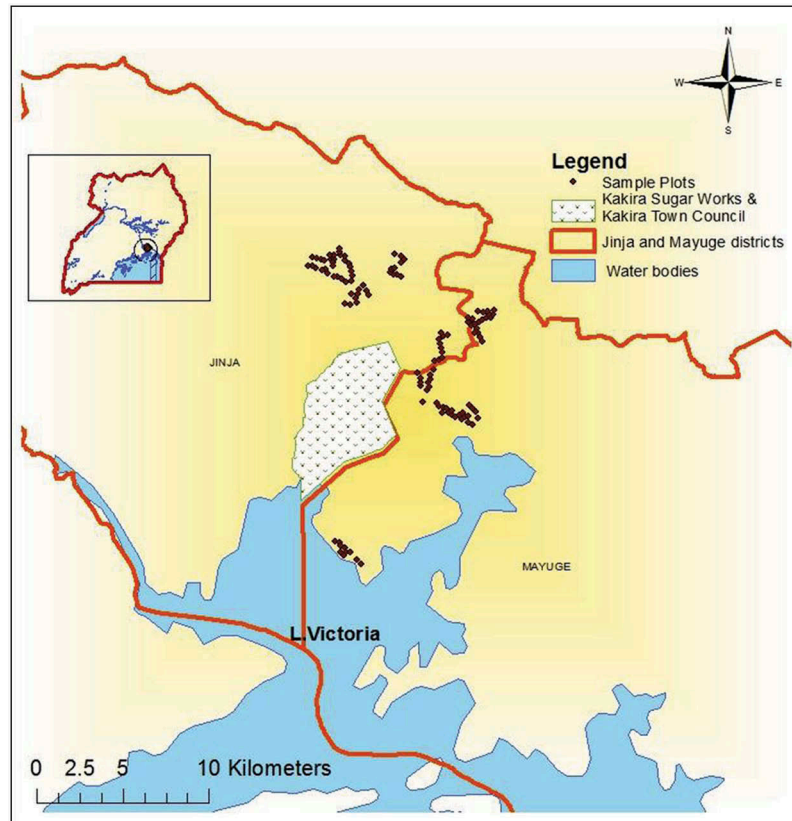


Figure 1. Study area showing the 120 sampling sites (·) within a radius of 21 km from Kakira Sugar Works Limited in the commercial sugarcane cultivation villages of Jinja and Mayuge districts, eastern Uganda.

The local population in most parts of Jinja and Mayuge districts are subsistence farmers who mainly grow food crops, such as banana, maize, cassava, potatoes and beans that also serve as cash crops. Traditionally, they grew coffee and cotton as the main cash crops, but with a global slump in prices for cotton and coffee, they were replaced by commercial sugarcane cultivation in monoculture plantations by small-scale farmers under an out-growers scheme and by companies including KSWL. This has led to extensive loss of natural ecosystems and their goods and services, as well as reduction in land available for food crop cultivation. Over 15 years ago, this sub-region was predominantly a coffee–banana agro-ecological zone of Uganda.

Sampling design

Within each district, one sub-county among those adjacent to KSWL and practicing commercial sugarcane cultivation was selected purposively for the study. For Mayuge district, Baitambogwe sub-county was selected while Busedde sub-county was selected for Jinja district. Baitambogwe sub-county consists of eight parishes while Busedde sub-county has five parishes. A total of 12 villages were selected from the 13 parishes. Within each village, 10 homegardens were chosen purposively and their locations recorded using a GPS. Since homegardens have a high spatial

variability and prevent the use of the standard plot sizes (Zarin et al. 2002), like 20 × 20 m plots, the entire homegarden was considered as a sample plot and surveyed. Sugarcane plantations were not sampled since they were monocultures devoid of plant agrobiodiversity and any agroforestry practices given their nature of management.

Data collection

Each entire homegarden was sampled for agrobiodiversity and all plants encountered enumerated, identified and recorded as present or absent in both scientific and local name. The Flora of Tropical East Africa (FTEA) (Polhill 1952 *et seq.*) was used to identify plants in the field. Voucher specimens of species that could not be identified or only be identified by local name in the field were collected, pressed and subsequently identified at Makerere University Herbarium, Botany Department (MHU), Kampala, Uganda. The trends in agrobiodiversity over the years and its contribution to local livelihoods were assessed using a face-to-face questionnaire (Appendix 1) interview of the 120 household heads (assumed to be the keeper for the sampled homegarden) comprising 10 from each of the 12 villages. The aim was to document the uses for the plants, land use type and type of ownership of the land and plants. Data collection was carried out between July 2012 and February 2013.

Ethical consideration

Respondents were allowed to exercise their right to voluntarily accept or refuse to participate in the study. They were also assured of confidentiality and anonymity.

Data analysis

Homegardens were characterized in terms of species presence/absence, species richness, diversity (i.e. α -diversity based on Shannon–Wiener Diversity Index – H') and similarity (Table 1). For each village homegardens, species area curves were constructed using Species Diversity and Richness (SDR®) Version IV Software (Seaby & Henderson 2006). In this construction, a step-wise calculation of cumulative species richness as data from each replicate sample plot are added to the total village species richness approach was used. Variation in species composition

among the sampling plots was calculated using the ANalysis Of SIMilarity (ANOSIM) Index technique in Community Analysis Package (CAP®) Version IV (Seaby & Henderson 2006). We assessed the relationship between the frequency of mention of the plant as useful and its abundance (or availability) using the Spearman rank correlation in Minitab 16 Statistical Software (MINITAB 2010).

Results

Agrobiodiversity in the homegardens

A total of 68 plant species, representing 46 genera and 27 families were recorded in the 120 homegardens selected from the 12 villages (Table 2). The species accumulation (Sp. Acc.) curve reached an asymptote, showing that species richness was not far from being completely recorded for this landscape (Figure 2). The flattening of the species accumulation

Table 1. A brief description of the diversity indices and measures of similarity applied in the analysis of the plant species data from the 120 homegardens in the sugarcane cultivation villages of Jinja and Mayuge districts, eastern Uganda.

Index/measure	Description
<i>Diversity indices</i>	
Shannon–Wiener (H') (Seaby & Henderson 2006)	Shannon index gives a measure of both species numbers and the evenness of their abundance; the resulting figure does not give an absolute description of a site's biodiversity. It is particularly useful when comparing similar ecosystems or habitats, as it can highlight one example being richer or more even than another
<i>Similarity analysis</i>	
ANalysis Of SIMilarities (ANOSIM) (Seaby & Henderson 2006)	It is a multi-variate, non-parametric measure that provides a way to test statistically whether there is a significant difference between the two or more groups of sampling units
SIMilarity PERcentages (SIMPER) (Seaby & Henderson 2006)	Breaks down the contribution of each species to the observed similarity (or dissimilarity) between samples. It allows the user to identify the species that are most important in creating the observed pattern of similarity

Table 2. List of plant species encountered across all the 120 homegardens in the sugarcane cultivation villages of Jinja and Mayuge districts, eastern Uganda.

Scientific name	Family	Scientific name	Family
<i>Albizia coriaria</i> Welw.	Leguminosae	<i>Manilkara dawei</i> (Stapf) Chiov.	Sapotaceae
<i>Aleurites moluccana</i> (L.) Wild.	Euphorbiaceae	<i>Melia azedarach</i> L. ¹	Meliaceae
<i>Alstonia boonei</i> De Wild.	Apocynaceae	<i>Milicia excelsa</i> (Welw.)C.C. Berg.	Moraceae
<i>Annona reticulata</i> L. ²	Annonaceae	<i>Morinda lucida</i> A.Gray. ²	Rubiaceae
<i>Antiaris toxicaria</i> (Pers.) Lesch. ¹	Moraceae	<i>Moringa orifera</i> Lam	Moringaceae
<i>Artocarpus heterophyllus</i> Lam	Moraceae	<i>Musa</i> spp.	Musaceae
<i>Azadirachta indica</i> A. Juss	Meliaceae	<i>Parinari curatellifolia</i> Planch. Ex Benth. ²	Chrysobalanaceae
<i>Canarium schweinfurthii</i> Engl	Burseraceae	<i>Persea amaericana</i> Mill.	Lauraceae
<i>Carica papaya</i> L.	Caricaceae	<i>Piliostigma thonningii</i> (Schumach.) Milne. Redh. ¹	Leguminosae
<i>Cassia siamea</i> Lam. ¹	Leguminosae	<i>Pinus</i> spp.	Pinaceae
<i>Ceiba petandra</i> (L.)Gaertn. ¹	Malvaceae	<i>Pseudospondias microcarpa</i> Engl. ¹	Anacardiaceae
<i>Citrus sinensis</i> (L.) Osbeck.	Rutaceae	<i>Psidium guajava</i> L.	Myrtaceae
<i>Coffea robusta</i>	Rubiaceae	<i>Ricinus communis</i> L. ¹	Euphorbiaceae
<i>Eucalyptus</i> spp.	Myrtaceae	<i>Sapium ellipticum</i> Pax	Euphorbiaceae
<i>Euphorbia tirucalli</i> L. ¹	Euphorbiaceae	<i>Senna spectabilis</i> (DC) H.S. Irwin & Barneby	Fabaceae
<i>Ficus amadiensis</i> De Wild.	Moraceae	<i>Spathodea campanulata</i> P. Beaux	Bignoniaceae
<i>Ficus exasperata</i> Vahl. ³	Moraceae	<i>Stereospermum kunthianum</i> Cham.	Bignoniaceae
<i>Ficus mucoso</i> Welw. Ex Ficalho. ¹	Moraceae	<i>Symphonia globulifera</i> L.f	Guttiferae
<i>Ficus natalensis</i> Hochst	Moraceae	<i>Syzygium cumini</i> (L.) Skeels. ²	Myrtaceae
<i>Ficus ovata</i> Vahl.	Moraceae	<i>Tamarindus indica</i> L.	Leguminosae
<i>Ficus platyphylla</i> Delile	Moraceae	<i>Terminalia brownii</i> Fresen. ¹	Combretaceae
<i>Ficus saussureana</i> DC ¹	Moraceae	<i>Terminalia laxiflora</i> Engl.	Combretaceae
<i>Ficus sur</i> Forssk	Moraceae	<i>Theobroma cacao</i> L. ²	Malvaceae
<i>Gravillea robusta</i> A.Cunn ex R.Br. ²	Proteaceae	<i>Thevetia peruviana</i> K. Schum.	Apocynaceae
<i>Measopsis eminii</i> Engl.	Rhamnaceae	<i>Trema orientalis</i> (L.) Blume. ¹	Cannabaceae
<i>Markhamia lutea</i> K. Schum	Bignoniaceae	<i>Vernonia amygdalina</i> Delile	Combretaceae
<i>Mangifera indica</i> L.	Anacardiaceae	<i>Vitex fisheri</i> Gurke. ¹	Verbenaceae

¹Plant species recorded only in the selected village homegardens of Mayuge district.

²Plant species recorded only in the selected village homegardens of Jinja district.



Figure 3. A homegarden maintained using agroforestry practices in one of the sugarcane cultivation villages of Jinja and Mayuge districts, eastern Uganda. The crops here included cassava (*Manihot esculenta*), maize (*Zea mays* L), coffee (*Coffea* sp.), bananas (*Musa* spp.) and agroforestry trees (e.g. *Maesopsis eminii*).

considered important and most cultivated in the homegardens. The area cultivated per household is small (approximately 0.4 ha/household) and continues to decline as much of the arable land is converted to monoculture sugarcane plantations. There was no significant association between the socio-economic factors (i.e. age of respondents, size of homegardens, sex of respondent and education status) and the crops grown in the homegardens ($p > 0.05$) for all the pairwise comparisons. On the other hand, the frequency of mention of a plant as useful was significantly correlated (Pearson correlation = 0.829, $p < 0.05$) with its abundance in the area. This suggests that crops that were more abundant were highly likely to be reported as useful by many respondents.

Farmers reported the following challenges in maintaining indigenous crops: limited land for crop cultivation (71%), pests and diseases (59.18%), extreme weather conditions (15.51%), low yields (10.20%) and low soil fertility (13.06%), lack of market for traditional crops, old age of farmer and labour-intensive agricultural practices. Limited land was cited as the most common reason for abandoning cultivation of some of the food crops, as most of the land, which was previously available for crop cultivation is now rented out for commercial sugarcane growing in both districts. Consequently, households had abandoned growing of key indigenous food and cash crops such as finger millet, cowpeas, groundnuts (including bambara groundnuts), soya beans, oyster nut, aerial yams and cotton.

Discussion

Plant diversity and composition in homegardens

Homegardens throughout the tropics are recognized as loci for in-situ conservation of agrobiodiversity

(Altieri et al. 1987) particularly in subsistence agricultural systems, but diversity therein varies according to ecological and socio-economic factors (Christanty et al. 1986). In the current study, a variety of plants were maintained in homegardens, with an alpha diversity (H') greater than 1 for the majority of homegardens. The H' value is within the reported range of 0.93–3.0 for tropical homegardens (Karyono 1990; Drescher 1998; Kehlenbeck & Maass 2004); and shows a high species diversity (Pinedo-Vasquez et al. 2000). However, the total plant diversity, number of useful plant species and diversity is low compared to what has been recorded in other parts of Uganda (e.g. Eilu et al. 2003), and elsewhere in the tropical world (e.g. Karyono 1990; Soemarwoto & Conway 1992; Abdoellah et al. 2001; Wezel & Bender 2003; Perrault-Archambault & Coomes 2008). Despite the small sizes of homegardens (average size 0.25–0.5 acres), a single plot contained almost all categories of crops, since it is the only available land for crop cultivation.

The homegardens differed significantly in species composition, which can be attributed to differences in household's needs and preferences that depend on the type of foods eaten in the households and the agricultural practices. Although most households grow coffee, their choice of shade trees (i.e. agroforestry practices) varies, contributing to the overall heterogeneity of tree and crop species in this commercial sugarcane plantation matrix. Household socio-economic characteristics (i.e. age and sex of respondent, size of homegarden and level of education) did not influence variation in species composition and diversity among the homegardens. This contrasts with other studies that found species composition of homegardens to be attributed to a variety of socio-economic and demographic conditions of the farmers (e.g. Christanty et al. 1986; Bellon &

Brush 1994; Quiroz et al. 2002; Zimmerer 2003; Kehlenbeck & Maass 2004; Perales & Brush 2005; Perreault 2005), size of homegarden (Abdoellah et al. 2001; Perrault-Archambault & Coomes 2008), distance to urban markets and ethnicity (Lamont et al. 1999; Kehlenbeck & Maass 2004; Wezel & Ohl 2005). The lack of association between homegarden species composition and socio-economic characteristics of households suggests other overriding factors such as sugarcane cultivation and ecological attributes such as weather and edaphic factors in the area. Garden diversity could vary according to ecological factors of gardens (Christanty et al. 1986), and species number and diversity are reportedly influenced by altitude of homegardens (Karyono 1990; Quiroz et al. 2002), homegarden size (Abdoellah et al. 2001) and level of production intensity and market access (Michon & Mary 1994; Peroni & Hanazaki 2002). The significant correlation between the frequency of mention of useful plants and their abundance suggests that such plants are highly likely to be reported as useful by a high number of respondents. This also suggests that such plants may be more available or visible to the communities (e.g. Phillips & Gentry 1993; Lucena et al. 2012; Linstädter et al. 2013; Ribeiro et al. 2014), for example, maize, bananas, coffee and cassava.

Although the homegardens differed significantly in species composition, they shared some common species, and common crops such as coffee, bananas, cassava and maize that were frequently encountered. The high contribution of *Coffea robusta* L., *Musa* spp., *Artocarpus heterophyllus* Lam, *Mangifera indica* L. and *Makharmia lutea* K. Schum to the average similarity among the homegardens studied suggests that households across all villages similarly valued these plants. While the maintenance of multi-purpose plants (i.e. for food, fuelwood and income) within the homegardens, is because land gets scarce and farmers invest energy in planting and maintaining plants for various home and commercial uses (Place & Otsuka 2000; Bolwig et al. 2006). Farmers prefer to grow crops that provide food and incomes (Hoogerbrugge & Fresco 1993; Mitchell & Hanstad 2004). On the other hand, bananas are usually planted with nurse trees, which account for the abundance of fuelwood and fruit trees in the homegardens.

Benefits of homegardens to households and trends in agrobiodiversity

Agrobiodiversity in the homegardens in this area forms the basis for household food production, income generation and domestic biomass energy needs thereby, enhancing rural household livelihoods. Similar findings have been reported elsewhere (Akinnifesi et al. 2010; Albuquerque et al. 2005). Homegardens wherever they occur, are characterized

by a structural complexity and multi-functionality, which enables the provision of different benefits to people (Galluzzi et al. 2010). More notably they serve as a source of food supply ensuring food security and improved nutrition for households (Dyg & Phithayaphone 2004; Mitchell & Hanstad 2004). Furthermore, agrobiodiversity plays a pivotal role in sustaining and strengthening food, nutrition, health, domestic energy needs and livelihood security (Frei & Becker 2004; Toledo & Burlingame 2006), and is therefore essential for the survival and well-being of the human population. In the study area, bananas and coffee are the major sources of food and income. The presence of coffee plantations will contribute to biodiversity sustainability in the area compared to monoculture sugarcane plantation. Therefore, the conservation of cultivated plants in homegardens provides significant economic and nutritional benefits for the rural poor (Thrupp 2000; Eyzaguirre & Linares 2004; Kumar & Nair 2006).

The study area continues to experience a decrease in agrobiodiversity as the traditional food crops, such as cowpeas, soya beans, bambara groundnuts, finger millet, cotton, aerial yams and oysternut have been lost or abandoned by households. This loss of agrobiodiversity is mainly attributed to increasing commercial monoculture sugarcane cultivation that has occupied land that would be used for indigenous crops cultivation. Similarly, changes in land-use patterns leading to loss of traditional agroecosystems is one of the main causes of disappearance of traditional crop species and threatening extinction of some in western Nepal (Sunwar et al. 2006; Galluzzi et al. 2010), and south-western China (e.g. Fu et al. 2005, 2008, 2009). The abandonment or loss of groundnuts/peanuts (including bambara nuts) and cotton from the subsistence agricultural system in the study area has also been reported in Asia by Fu et al. (2008).

Commercialization of agriculture that includes commercial monoculture sugarcane growing has been cited as the main cause of biodiversity loss including food crop diversity loss in many parts of the tropical world (Altieri et al. 1987; FAO 2004). Commercial monoculture sugarcane growing has been shown to be a major contributor to indigenous agrobiodiversity (i.e. food crops and vegetable) loss in sugar belts of western Kenya (Netondo et al. 2010), and has replaced crops, such as rice, cassava and maize. In the study area, sugarcane cultivation is perceived by households as the most profitable crop because of the assured market from sugar corporations operating in the area. This has also been exacerbated by the dwindling world market for other cash crops like coffee, thus leaving the local communities with no option but to concentrate on sugarcane. Commercial sugarcane cultivation and the

attendant unsustainable land management practices (i.e. intensive and extensive destruction of natural ecosystems) renders the soils infertile (Clay 2004) and adversely affects crop production (Liwenga & Kangalawe 2009) and ultimately leads to loss of indigenous food crops from the subsistence agricultural system and reduced ecosystem services from agrobiodiversity.

Conclusions

The high diversity of indigenous crop species in homegardens implies that the local communities in Jinja and Mayuge districts still appreciate their value in addressing household needs. The results of this study imply that the most important plants to households are the ones that are often maintained in homegardens. Multi-purpose plant species, such as maize, cassava, beans, bananas, coffee and fruit trees dominated the homegardens. Food, income from sales of crops maintained, fuelwood, timber and shade from trees are the benefits households derive from their homegardens. However, cultivation of crops, such as finger millet, cowpeas, local land races of groundnuts (such as bambara groundnuts), soya beans, oysternut, aerial yams and cotton has declined in villages where sugarcane is commercially cultivated. Our findings underline the importance of homegardens in the conservation of indigenous agrobiodiversity, and indicate that with the continued expansion of commercial sugarcane cultivation this opportunity may be lost. There is a need to adopt agroforestry practices to support biodiversity conservation in homegardens and surrounding farmed landscapes; and judicious planning of commercial sugarcane cultivation to reduce agrobiodiversity erosion. An improved understanding of the household management decisions of homegardens may benefit from the use of various 'Use Indices' that take into account the general, current and potential uses in evaluating the usefulness of plants maintained therein.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Appendix 1. A research questionnaire focusing on the contribution of agrobiodiversity to rural household livelihood strategies in the sugarcane cultivation villages of Jinja and Mayuge districts, eastern Uganda

MAKERERE UNIVERSITY RESEARCH QUESTIONNAIRE

Dear respondent, this questionnaire is designed for academic purposes only and any personal information obtained will be kept confidential. The topic of the research is 'CONTRIBUTION OF BIODIVERSITY TO RURAL LIVELIHOODS'. We request for an interview with you, but you are free not to answer any of or all the questions if you do not feel comfortable. You are also free to withdraw from the interview at any time without any worries. We look forward to your cooperation to make this study a success.

- a) District..... c) Parish
- b) Sub-county..... d) Village.....
- e) Household/Homegarden No.....

SECTION A: BIO DATA

- a) Sex of Respondent: Male [] Female []
- b) What is your level of education attained? (i) Non-formal education [] (ii) Primary [] (iii) Secondary [] (iv) Post-Secondary []
- c) Age
- d) Number of children.....

SECTION B: CROPS

1. What is the approximate size of your homegarden?
.....
.....
2. What are the reasons for maintaining this homegarden?
.....
.....
3. List some of the challenges you face in maintaining this homegarden.
.....
.....
4. List the benefits you derive from maintaining your homegarden.
.....
.....
5. Which crops do you maintain in your homegarden?
.....
.....
6. Which of those crops are considered most important to local livelihoods and why?
.....
.....

-
.....
7. Which benefits do local households derive from the crops found within the villages?
.....
.....
8. List the other crops that you used to grow on your farm but no longer cultivate.
.....
.....
9. Why have you stopped growing those crops?
.....
.....
10. Which benefits did you derive from those crops?
.....
.....
11. Do you have alternative crops that have replaced the disappeared crops?
.....
.....
12. What effect does the disappearance of these crops have on your livelihood?
.....
.....
13. What measures or alternative activities do you have in place to minimize the effects in (8) above?
.....
.....